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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/659,060	09/09/2003	Peter J. De Groot	09712-332001 / Z-433	3834
26161	7590	09/27/2005	EXAMINER	
FISH & RICHARDSON PC P.O. BOX 1022 MINNEAPOLIS, MN 55440-1022			DETSCHER, MARISSA	
			ART UNIT	PAPER NUMBER
			2877	

DATE MAILED: 09/27/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

**Office Action Summary**

Application No.

10/659,060

Applicant(s)

DE GROOT, PETER J.

Examiner

Marissa J. Detschel

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1) ☒ Responsive to communication(s) filed on 09 September 2003.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

- 4) ☒ Claim(s) 1-55 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-18, 20-22, 24-26, 29-50, and 52-55 is/are rejected.
- 7) ☒ Claim(s) 4, 5, 19, 23, 24, 27, 28, 31, 51 and 53 is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some \* c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
  2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

- |  |   |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)                        | 4) <input type="checkbox"/> Interview Summary (PTO-413)                     |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)               | Paper No(s)/Mail Date. _____  |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| Paper No(s)/Mail Date <u>3/15/04, 2/12/04</u>  | 6) <input type="checkbox"/> Other: _____                                    |

## **DETAILED ACTION**

### ***Information Disclosure Statement***

The information disclosure statements filed on February 2, 2004 and March 15, 2004 have been fully considered by the examiner.

### ***Claim Objections***

Claims 4, 5, 24, 31, and 53 are objected to because of the following informalities:

In regards to claim 4, the word "relate" appears at the beginning of the second line of this claim. This word should be "relates" in order for the claim to be grammatically accurate.

In regards to claim 5, the limitation "the multiple locations" is recited in this claim, and there is insufficient antecedent basis for this in relation to claim 4. Examiner suggests making claim 5 dependent on claim 3, rather than claim 4. Furthermore, the word "comprises" is used in the first line of this claim, but should be "comprising" in order for the claim to be grammatically accurate.

In regards to claim 24, lines 3 and 4 on page 28 appear to be missing a "to" after the word "proportional" in line 3.

In regards to claim 31, the limitation "the complex reflectivity" appears in this claim, and there is insufficient antecedent basis for this.

In regards to claim 53, the word "a" appears in the second line of this claim, and should be replaced with "at" for the claim to make sense.

Appropriate correction is required.

### ***Claim Rejections - 35 USC § 112***

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The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Claims 31-33, 39 and 41 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claims 31-33 recite the limitation "complex reflectivity"; Claims 39 and 41 recite the limitation "the complex reflexivity." What is complex reflexivity and how is it different from complex reflectivity? Applicant fails to disclose the meaning of complex reflexivity in the specification, and no discretion is made against complex reflectivity. Examiner is unable to find a definition for "complex reflexivity" in any outside source.

Claim 40, which is dependent from claim 39, inherits the problems of these claims, and is therefore also rejected under 35 U.S.C. 112, second paragraph.

### ***Claim Rejections - 35 USC § 102***

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

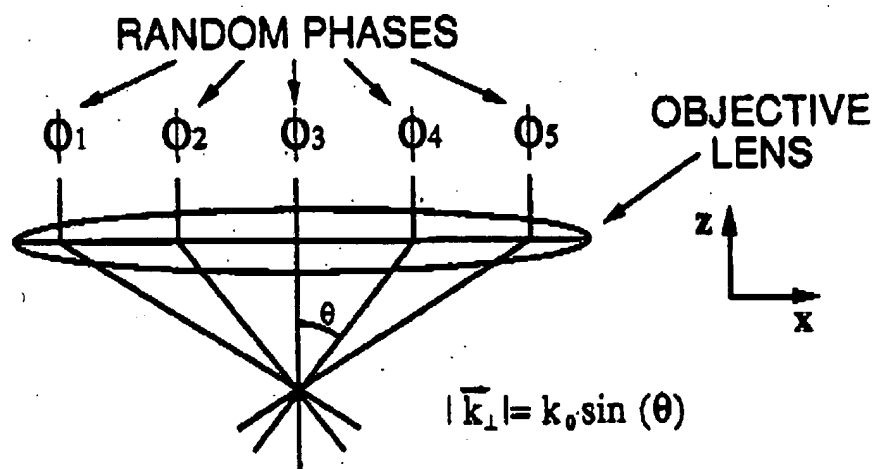
A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 1-7, 10-12, 20, 21, 35, and 54 are rejected under 35 U.S.C. 102(b) as being anticipated by Davidson, et al. (USPN 5,112,129).

In regards to claim 1, Davidson discloses a device that images light from a source (31) onto a test object (16) over a range of angles (see Figure 3) to interfere with reference light on a detector (36, 22). A portion of figure 3 (below) has been provided in

this office action to further illustrate this disclosure. Davidson's device includes a piezoelectrical vertical motion system (18) that scans the test object over a range of z-positions (column 8, lines 39-40). An angle-dependence is determined of an optical property of the test object based on the interference between the test and reference beams of light (see Figure 3) as the optical path length difference is varied by the scanning of the piezoelectric vertical motion system (column 8, lines 39-43).



Regarding claim 2, the detector (22) of Davidson's device is a video camera capable of imaging the test light emerging from different locations of the test object.

In regards to claim 3, the angle-dependence of the optical property of Davidson's device is determined at each of the different locations of the test object (A, C, and B of figure 6a).

Regarding claims 4-6, the angle-dependence of the optical property of Davidson's device is a function of the angle of the test light incident on multiple locations of the test object. An objective lens is used to illuminate and image the multiple locations of the test object. (See figure above)

In regards to claim 7, the common source used in Davidson's device can be a spatially extended coherent source (column 3, line 63 to column 4, line 2).

In regards to claims 10-12, the angle dependence of the optical property of Davidson's device is a function of the angle of the test light scattered from the test object. The multiple locations of the test light having a uniform angle of incidence on the test object are illuminated by the source (31) and the light scattered over a range of angles at different locations are imaged by a video camera (22). The illuminating and imaging involve a common objective lens. (see Figure 3, as shown above)

Regarding claim 20, the test object of Davidson's device sits on a piezoelectrical vertical motion system (18) that scans the test object over a range of z-positions (column 8, lines 39-40) during measurements relative to the objective lens.

Regarding claim 21, Davidson discloses that the path length variation of the device can include variations in the part of the beam between the objective lens and the reference mirror (column 2, lines 59-64). This involves movement of the reference mirror to vary the optical path length.

In regards to claim 35, Davidson discloses a method for determining the surface height profile of the test object (i.e. the top width, bottom width, and height of an integrated circuit line) based on the interference between the test and reference light (column 2, lines 20-24).

In regards to claim 54, Davidson's device includes a source module (lamp, condenser lens, filters, diffuser, aperture stop, field stop, and a final collimating lens) configured to illuminate the test object with collimated light (see Figure 1).

Claims 44-46, 48, and 49 are rejected under 35 U.S.C. 102(b) as being anticipated by Gold, et al. (USPN 4,999,014).

In regards to claim 44, Gold discloses a device that determines an angle-dependence of an optical property (i.e. thickness) of a test object (i.e. thin film) based on interferometry data for the test object in the form of angular dependent intensity measurements (Abstract, lines 7-13). The test object sits on a stage that is capable of moving in the X and Y directions, creating a scanning means (column 11, lines 16-22).

Regarding claims 45 and 49, the light source used in the Gold device is a laser that generates light of a single wavelength (i.e. monochromatic light). (column 3, lines 24-30)

Regarding claim 46, the device of Gold comprises an electronic processor (24) that is coupled to the detector and scanning interferometer that is configured to determine an angle-dependence of an optical property from interference between the test and reference beams (Figure 12).

Regarding claim 48, the device of Gold includes a processor that determines the thickness of the test object (thin film) based on the angular dependent intensity measurements (column 12, lines 30-35).

### ***Claim Rejections - 35 USC § 103***

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the

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invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claims 8, 9, 14, and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Davidson, et al., as applied to claims 5 and 11 above, and further in view of Gold et al. (USPN 4,999,014). Davidson does not disclose the details of the numerical aperture of the lens used in their device. However, Gold discloses the use of a lens having a numerical aperture of 0.95 in their device for measuring the thickness of thin films. The use of this lens results in a spread of the incident angles of greater than 70 degrees. (column 5, line 68 to column 6, line 2) Therefore, it would have been obvious to one in the art at the time the invention was made to apply the high numerical aperture lens of Gold to the device of Davidson in order to maximize the spread of the angles of incidence on the test object to get a better measurement of the angle-dependence of the optical property.

Claims 13, 18, 24-26, 29, 30, 43, 47, and 55 are rejected under 35 U.S.C. 103(a) as being unpatentable over Davidson as applied to claims 1, 46, and 55 above, and further in view of de Groot (USPN 5,398,113).

In regards to claims 24-26, 29, and 30 the device of Davidson does not involve a transformation of the interference signal with respect to a coordinate linearly proportional to the optical path difference for each of the angles to produce a transformed signal that depends on the conjugate variable to the coordinate. De Groot discloses that in monochromatic two-beam interferometry, a pattern of sinusoidal fringes of spatial frequency  $k$ , and phase  $\phi$  are generated in space. The relation between  $k$  and  $\phi$  is given as  $\phi = k \cdot Z$ , where  $Z$  is the optical path difference. The sinusoidal fringes



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represent an interference signal. In regards to claim 25, the spatial frequency found in de Groot's analysis represents the conjugate variable. Regarding claim 30, this mathematical analysis represents a Fourier transform in the spatial frequency domain. The Fourier analysis further includes the possibility of recovering the interference fringe patterns for the purposes of determining their relative strength and phases. In regards to claims 26 and 29, the fringe patterns are directly related to the angle of the incident light on the test object, and therefore, a visual representation of the angle-dependence of the optical property. The method of Fourier analysis in the form of a transform in the spatial frequency domain has been known and forms the basis of the modern science of Fourier transform spectroscopy. (column 7, lines 22-56). Therefore, it would have been obvious to one skilled in the art at the time the invention was made to apply this Fourier analysis to the device of Davidson since it is known fact.

In regards to claims 13, 18, 43, 47, and 55, Davidson does not disclose the use of a monochromatic light source in their device. The device of Davidson can be used to find the thickness of a thin film as a test object (column 3, lines 1-2). De Groot discloses the use of a narrow-band (i.e. monochromatic and point) source in an interferometry device when testing a device with an unknown composition. With this source, accurate measurements are made that are independent of any optical phase change introduced by reflection of the source from the test object surface. (column 12, lines 28-40) Therefore, it would have been obvious to one skilled in the art at the time the invention was made to use the narrow-band source of de Groot in Davidson's device to accurately measure test objects of an unknown composition.

Claims 16, 17, 50, 52, and 53 are rejected under 35 U.S.C. 103(a) as being unpatentable over Davidson as applied to claim 1 above, and further in view of Sinclair, et al. (USPN 6,721,094).

In regards to claims 16, 17, and 50, Davidson does not disclose the method of polarizing the test light in a pupil plane of the optical system used to illuminate the test object using polarization optics. Sinclair discloses the use of a one-quarter waveplate (46) located between the beamsplitter (18) and objective lens (12) that allows all of the light reflected from the test object to pass onto the imaging section of the Linnik microscope. As to claim 52, the beamsplitter (18) of Sinclair's device can be a polarizing beamsplitter (column 7, lines 14-15), and is used in the optical system with a one-quarterwave plate (46). As to claim 53, Sinclair discloses the use of a one-quarter waveplate (48) located between a reference mirror and a beamsplitter that allows all the light reflected from the reference mirror (26) to pass through the beamsplitter and onto a CCD camera (54). Polarized optics are useful in reducing optical feedback to the light source of the optical system. (column 7, lines 18-27) Therefore, it would have been obvious to one skilled in the art at the time the invention was made to apply the polarization optics of Sinclair to Davidson's device to create a clearer signal, and thus a more accurate measurement of the angle-dependency of the optical property.

Claims 22 and 36-38 are rejected under 35 U.S.C. 103(a) as being unpatentable over Davidson as applied to claim 1 above, and further in view of Kim et al., (USPN 6,545,763). Davidson does not disclose the method of moving a beam splitter positioned in a Mirau interference objective to vary the optical path length for each of

the angles. Kim discloses the use of a body tube (409) built in a piezoelectric transducer (407) that obtains the interference signal as it is moved in a direction of optical axis at minute intervals in the z-direction. The beamsplitter (410) is also included in the body tube, and therefore moves with the motion provided by the piezoelectric transducer.

(column 10, lines 43-49) This allows for the most intensive interference signal to occur at the measurement point of the detector for the device (column 10, lines 50-55).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the Mirau optical interferometry system of Kim in Davidson's device to get the most intensive signal of the measurement point, in order to gain more accurate measurements of the angle-dependence of the optical property.

In regards to claims 36-38, Davidson does not disclose the method of comparing the angle-dependent changes in the optical property of a test object to those of a model for the test object. Kim discloses a method for measuring the thickness of transparent dielectric-thin-films using white-light scanning interferometry (column 3, lines 13-17). During measurement, two phase graphs of the measurement object are extracted - a phase graph of a test object is acquired from an interference signal and a mathematical phase graph through modeling. An error function is determined by comparing these two phase graphs, and a thickness value for the test object is found by applying optimization techniques to this error function (column 3, lines 21-29). The phase graphs are representations of angle-dependent changes in optical property. It would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the technique of Kim involving the two phase graphs to the device of Davidson in order to

account for error in measurement, and to make sure the device is making accurate measurements of the angle-dependency of the optical property of the test device.

Claim 34 is rejected under 35 U.S.C. 103(a) as being unpatentable over Davidson as applied to claim 1 above, and further in view of Davidson (USPN 4,818,110). In Davidson's first Linnik microscope, Davidson does not disclose the use of precalibrated angle-dependent characteristics in determining and angle-dependence of an optical property. However, in Davidson's second Linnik microscope, Davidson discloses the setup involving a surface mirror as a test object and a window in the center of the image plane prior to the measurement for the angle-dependence (coherence, C) of a wafer. The reference and object beams are focused and the path is adjusted so the fringe amplitude is the greatest at the center of the window. This allows for all parts of the test surface that are at the same level as the surface of the reference mirror to be imaged brightly, indicating good coherence and bright fringes. (column 5, lines 52-68) Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the calibration technique of Davidson's second device to Davidson's first device to assure that the optical parts are aligned properly, leading to more accurate measurements of angle-dependence.

Claim 42 is rejected under 35 U.S.C. 103(a) as being unpatentable over Davidson as applied to claim 1 above, and further in view of Greenberg, et al. (USPN 5,042,949). Davidson does not disclose using a second wavelength to repeat the imaging, varying, and determining for the test and reference light in their device. Greenberg discloses using a filter wheel (16) in a Linnik interferometer for measuring

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optical properties of test objects that consist of an opaque material in phase measuring interferometry (column 3, lines 33-36). The interference patterns that are formed for each wavelength are representative of the phase difference between the two interfering waves (column 3, lines 47-49). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the use of multiple wavelengths in Greenberg's interferometer to Davidson's device in order to measure the optical properties of opaque materials.

***Allowable Subject Matter***

Claims 19, 23, 27, 28, and 51 are objected to as being dependent on a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

As to claim 19, the prior art of record, taken alone or in combination, fails to disclose or render obvious the use of a source with a spectral bandwidth of less than 2% of the central wavelength in a scanning interferometer.

As to claim 23, the prior art of record, taken alone or in combination, fails to disclose or render obvious the method of varying the optical path length difference in a scanning interferometer for at least one of the angles over a range larger than the spatial coherence length.

As to claim 27 and 28, the prior art of record, taken alone or in combination, fails to disclose or render obvious the use of a direct mapping between the spatial frequency  $K$  and the angle  $\phi$  in the form of  $K(\phi)$  being proportional to  $\cos(\phi)/\lambda$ , where  $\lambda$  is the wavelength of the test light.

As to claim 51, the prior art of record, taken alone or in combination, fails to disclose or render obvious the use of a polarization optic that imparts a polarization that varies across the pupil plane.

**Conclusion**

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Marissa J. Detschel whose telephone number is 571-272-2716. The examiner can normally be reached on M-F 8:30am-5:00pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Gregory J. Toatley, Jr. can be reached on 571-272-2059. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

MJD



**HWA (ANDREW) LEE**  
**PRIMARY EXAMINER**